

PhD Proposal

**Online Routing Recommendations in Multimodal Transportation Networks:  
Impact, Potential Shortcomings, and their Mitigation**

Supervisors: [Paolo Frasca](#), [Alain Kibangou](#)

E-mail: [paolo.frasca@gipsa-lab.fr](mailto:paolo.frasca@gipsa-lab.fr), [alain.kibangou@gipsa-lab.fr](mailto:alain.kibangou@gipsa-lab.fr)

Duration: 3 years

Salary:  $\approx$  1500 euros per month after taxes + insurances

**Key dates:**

- For full consideration, contact the potential supervisors as soon as possible and no later than **June 30**.
- Mid-July: Selection completed.
- Fall 2021: PhD studies begin.

**Context:** This work will be carried out in the DANCE team (Dynamics and Control of Networks), a joint CNRS/INRIA research team at [GIPSA-Lab](#) laboratory in Grenoble, France. The team's research concerns modeling, estimation and control of network systems, with a broad spectrum of theoretical and applied topics including traffic networks, intelligent vehicles, social dynamics, and analysis of large-scale complex networks.

**Candidate profile:** The candidate will have a MS degree in Applied Mathematics, Control Systems, Electrical Engineering, or related disciplines.

**Topic description:** Nowadays, millions of users regularly seek routing advice from Online Routing Applications (ORAs) like Waze, Google Maps and TomTom. Their adoption is so pervasive that ORAs have the potential to influence the patterns of congestion in traffic networks and the modal split in multimodal transportation networks. Online routing can be seen as an example of "social feedback" from the users, where information is collectively gathered from and used to influence back a complex dynamical system, whose evolution depends on the users' choices. Online routing is in general formulated as a multicriteria optimization problem which is solved by the ORA to satisfy the user utilities, while the transportation network manager aims at optimizing some overall measure of the efficiency of the network. To fulfill its purpose, the network manager (at the level of a city, for instance, or at larger scale) has the possibility to intervene through multiple control actions (such as variable speed limits, ramp metering, access control, traffic lights) and by setting regulatory policies for the ORAs activities. It is therefore crucial for the network manager to understand the dynamics induced by ORAs in order to take adequate control actions and set effective regulatory policies.

Unlike most existing projects and works, which mainly study the problem from the service providers points of view in order to generate smart routing or parking recommendations, we adopt the point of view of the transportation network manager that seeks to optimize the overall system. This project therefore aims at (i) analyzing the effect of online routing on transportation network congestion; and (ii) introducing mitigation strategies against the adverse effects of ORAs through control actions (variable speed limits, ramp metering, access control, traffic lights) and regulatory policies (frequency of routing recommendations).

We will cast this problem into a modern control systems framework which includes two feedback loops that are closed around a plant, which is the multimodal transportation network. An inner feedback loop is produced by the ORAs, which set the (multimodal) split ratios by their routing recommendations. An outer feedback loop is produced by the network manager and its ability to intervene in the network through control actions on traffic lights, speed limits, lane allocation, and car parking supply. The project will be developed along three axes, which will constantly interact and support each other : Modeling (developing the suitable mathematical models to describe the overall system), Analysis & Design (Analysis and optimization of equilibria, analysis of dynamics, design of inner loop and outer loop interventions), and Simulations on Grenoble case study to validate models and findings. The analysis of the Grenoble case study will leverage the [GTL](#) and [GTL-Ville](#) experimental platforms that are run by the team.